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Potato scab and its prevention.

POTATO SCAB AND ITS PREVENTION.

Among the several diseases of the potato doing great injury none are more troublesome than potato scab. The theories and reasons assigned for the disease are numerous, but scientists have settled down to the conclusion that this disease is caused by a minute parasitic plant, known as *Oospora scabies*, Thaxter.[1] It will not be necessary in this connection to review the work of other investigators concerning the various theories. These briefly are chemical action, mechanical irritation, excessive moisture, and the insect theory, and the insect fungus theory of Hopkins. It will be well to briefly consider the nature of potato scab as shown by the investigations of mycologists.

Potato scab begins its work usually when the tuber is young, but sometimes attacks the potato at a more advanced stage. In places the potato becomes discolored. These commonly, but not always, have their origin in minute roughened points, known as lenticels; from these starting points it extends rapidly to other parts of the potato, forming a corky growth, so characteristic of potato scab. Potatoes freshly dug always show a peculiar "grayish mould." I have never failed to observe it in freshly dug specimens. This material on exposure to the air soon disappears.

Dr. Thaxter,[1] who discovered this organism, and has cultivated it in nutrient media, says: "Scrapings from the diseased surface, where this film was observed, when placed under the microscope, showed nothing characteristic which could be identified as connected with the object sought for, and the same result attended the examination of sections cut from the scab spots. The subject was then laid aside for a time until, on visiting the field from which the potatoes in question had been brought, it was found that the diseased tubers, which constituted a large percentage of the crop, in almost every case showed the more or less distinct presence of the same grayish material previously observed. In fact it

[1] Annual Report Conn. Agrl. Experiment Station, 1890. Page 84.

was invariably visible in the younger spots when due care was taken to uncover the potatoes so as to avoid unnecessary friction, and to examine them while still moist. When rubbed against the earth, or allowed to become dry, the gray material was often found to have disappeared entirely. Having ascertained that the appearance described was not local in any part of the field, but was present wherever diseased potatoes were examined, a number of the latter on which it was more conspicuous, were placed, while still moist, in a tight tin box, where they were left for twenty-four hours or more. At the end of this time the gray growth was on all the scab spots, and no difficulty was met with in taking enough of it on a needle to make sure of recognizing it under the microscope. It was then found to consist of bacteria-like bodies, with a strong tendency to cohere in an amorphous-looking mass, very repellant of water, and even to some extent of pure alcohol. The bodies themselves were rod-like, of various lengths, and among them spirally-coiled forms were peculiar and conspicuous. Pressure on the cover glass, applied to separate the mass, caused it to break up entirely into bacillus-like pieces, exactly resembling a group of minute bacteria."

This organism cultivated in nutrient media, slices of potato, potato agar and potato gelatin, grows in a very characteristic way. Cultures of these artificial growths, when used to inoculate sound potatoes, produce scab.

Prof. H L. Bolley[2] and Dr. J. C. Arthur[3] have shown that this same disease occurs on beets. It will be well enough to bear in mind the following suggestions: that potatoes should never follow sugar and other beets; nor should they follow Swedish turnips, carrots and cabbage, as these are also apparently affected, according to Prof. Bolley. It should also be remembered that best results have been attained in planting clean "seed" in clean soil. A soil that contains the scab organism will produce a scabby crop. Scabby potatoes planted in a clean soil will produce more scabby potatoes than where clean "seed" is used. As to the experimental work in treating the seed with fungicides, the first attempt was made by Prof.

[2] Bulletin No. 4, North Dakota Agrl. Exp. Station.
[3] Indiana Agrl. Exp. Station, Bulletin No. 39, page 60.
See, also, Iowa Agrl. Exp. Station, Bulletin No. 15, page 251.

Bolley,[4] who recommended the following formula and suggestions:

"Dissolve corrosive sublimate (bichloride of mercury) in water, at the rate of two and one-fourth ounces of the chemical to fifteen gallons of water. Immerse all potatoes to be used for 'seed' purposes in this solution one and one-half hours, after which they may be cut and planted as usual."

Corrosive sublimate is a strong poison, and great care should be taken that none of it is used internally.

To insure rapid solution the bichloride may conveniently be dissolved in a few gallons of hot water.

Corrosive sublimate corrodes metallic substances, and should thus be mixed in wooden vessels.

A large barrel will be found a convenient vessel in which to dip the potatoes.

"A loosely woven sack (coffee-sack) will be found suitable for dipping purposes."

"If the potatoes are very dirty it will be found expedient to wash them before treatment."

"After dipping spread the potatoes about, so that they will dry quickly."

The following are the conclusions found in experiments carried on in Michigan, by Prof. L. R. Taft and R. I Coryell:[5]

"1. Potato scab can be readily and cheaply controlled."

"2. Corrosive sublimate is the best remedy known as yet. Bordeaux mixture is promising."

"3. Ground once infected with scab will retain the germs for several years, and treating the seed for such ground will not be as effective."

"4. The treatment causes not only a more saleable product, but within the proper limits an increased yield."

"5. Corrosive sublimate, one part to 2,000, seems to be as effective as one part to 1,000. The latter strength is preferable, as the solution gradually loses strength."

"6. The best length of time to soak the seed is about one and one-half hours. A longer soaking may lessen the scab still more, but it reduces the yield."

[4] Bulletin No. 4 (1891), and No. 9 (1893), North Dakota Agrl. Exp. Station.

[5] Bulletin No. 108, Michigan Agrl. Exp. Station, Feb., 1894; page 44.

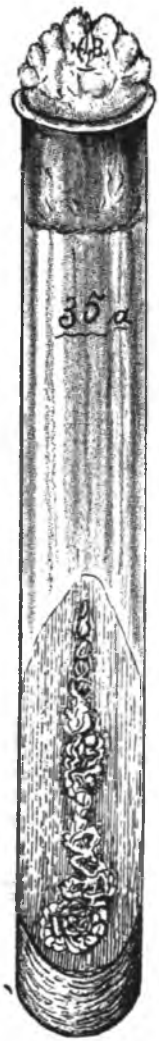

Fig. 1.

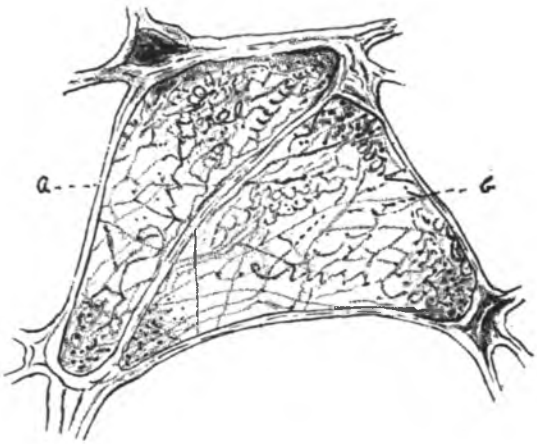

Fig. 2.

Fig. 3.—Potato scab.

Fig. 1. Potato scab organism growth on Agar. After Bolley.

Fig. 2. Cell showing scab organism. After Bolley.

Fig. 3. Potato with scab. After U. S. Dep't of Agriculture.

Prof. Chester,[6] who experimented with corrosive sublimate and Bordeaux mixture, says:

"Uniformly the effect of treating the seed with corrosive sublimate solution has been to diminish the amount of scab in the resulting crop, but not to the extent which might be expected after a study of Bolley's results."

"The treatment of seed with Bordeaux mixture did not in this case reduce the amount of scab in the resulting crop; on the contrary, there was more scab in the crop from seed so treated than in the crop from untreated seed."

Prof. L. F. Kinney[7] finds that in each case the product from the treated rows was less scabby than the product from the parallel rows that received no special treatment. The average excess of scab in the untreated rows being 74.4 per cent. The least amount of scab appearing on the product from rows where the seed tubers were soaked in a weak solution.

Bichloride of mercury has thus far given the best satisfaction by experimenters and growers, and in the proportion recommended by Bolley. We would advise the use of a standard solution, diluted to whateverproportion may in the future be found most effective. I believe it will be better to use muriatic acid (hydrochloric acid) in place of merely dissolving in hot water. Mr. Wood, of Baraboo, Wisconsin, who has successfully treated potato scab, added a small amount of muriatic acid to the bichloride, which aids greatly in dissolving. Muriatic acid has long been used for dissolving corrosive sublimate in bacteriological laboratories.

The Laplace solution is prepared as follows:

Corrosive sublimate.....200 grammes.
Hydrochloric acid (standard strength)..... ....One liter.
The above is a stock solution.
5cc of this to one liter of water.
Or, about one ounce of stock solution to five and one fourth quarts of water.

To prevent the precipitation of mercurial salts a small quantity of acetic acid should be added. Fürbringer recommends 0.5 gram to each liter of 0.1 per cent solution.

[6] Fifth Annual Report Delaware Agrl. Exp. Station, 1892; page 70.
[7] Fifth Annual Report Rhode Island Agrl. Exp. Station, 1893; p. 213.

OBJECTS OF OUR EXPERIMENTS.

The object of this experiment was to determine the value of different fungicides, as well as different lengths of time necessary to treat the seed.

Unfortunately the potato crop was nearly a failure. The seed was cut in halves, and the rows were planted east and west, comprising nearly an acre of ground. They received the same cultivation that other hoed crops had. It should also be stated that the field was clean, having been in cereals and grasses for several years.

Just as I am reading the revised proof, Indiana[8] and Rhode Island[9] Bulletins have come, in which potato scab is discussed.

Prof. Troop, of Indiana, concludes as follows: "It will be seen from the tables, 1st: That the per cent of scab, both on the treated and untreated, but especially on the latter, was very much greater on the muck than on the sandy loam. So that the comparative yield of marketable potatoes was very much greater on the upland than on the muck. 2d: That a sufficient number of germs remained in the soil from the previous year's crop to cause a very perceptible increase in the amount of scab on this crop. 3d: The per cent of scabby potatoes gradually decreased with the length of time they were in the solution; very little, however, after one and a half hours."

Wheeler, Towar and Tucker are strongly inclined to question if corrosive sublimate, or any other known treatment, will utterly destroy all the germs of contaminated seed tubers, even should seed be selected that is absolutely free from scab. It is no doubt true that the germs on potatoes are difficult to treat, but experiments have all been in the field, in which the organism may have occurred. In the summary of their work they conclude: "Experiments with air-slacked lime, covering a period of two years, show conclusively that it tends to increase the scab of potatoes. Since wood ashes contain about one-half as much lime in practically the same form,

[8] James Troop, Purdue University Agr'l Exp. Station, Bulletin 53; Volume 5, 1894; page 120.

[9] H. J. Wheeler, J. D. Towar and G. W. Tucker; Bulletin 30, 1894, Rhode Island Agricultural Experiment Station, page 66.

there remains almost no question but that they will also increase the scab. One ton of air-slacked lime contains in general a little less lime than two tons of wood ashes."

"It seems probable that the natural acidity or sourness of the soil tends to check the spread of the disease, and the tendency of barnyard manure to increase it may reasonably be attributed to its alkaline action, by which the sourness is overcome."

"If the farm stock is fed on scabbed beets or potatoes in an uncooked condition, then barnyard manure may still further increase the disease by carrying to the soil germs which have passed through the digestive organs of the animal undestroyed. If a soil is very acid small quantities of barnyard manure, wood ashes and air slacked lime will probably have far less tendency to increase the scab than when large quantities are used. The amounts which it would be safe to apply are doubtless dependent upon the sourness of the soil. The safest course, until absolutely effective means of disinfecting the seed tubers are found, would be to avoid these substances altogether, provided potatoes are to be grown successfully or in frequent rotation upon the same land. When grown under these conditions, the corrosive sublimate treatment proposed by Bolley has lessened decidedly the amount of scab."

BICHLORIDE OF MERCURY OR CORROSIVE SUBLIMATE.

Bichloride of Mercury, 2¼ oz.—64.25 grammes. Water, 15 gallons.

Seed Potato, Bonanza, quite free from scab.

No.	Time of planting.	Weight of seed.	No. of hills planted.	May 6th, No. up.	Very scabby.		Slightly scabby.		Clean.		Total.		Total scabby.		Time of application.
		Lbs.			Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	
1	4-24	12½	48	47	1	0	7	10	9	5	17	15	8	10	1 hour.
2	4-24	12½	48	48	1	13	4	10	11	10	18	1	6	7	1½ hours.
3	4-24	12½	48	47	0	0	4	1	8	9	12	10	4	1	2 hours.
4	4-24	12½	48	47	1	13	4	13	8	9	15	3	6	10	Check.
Total	.....	.....	.....	.....	4	10	21	2	38	1	.....	.....	....	.....	

The two hours had the least amount of scab.

AMMONIACAL CARBONATE OF COPPER.

Commercial Ammonia, 3 pts. Carbonate of Copper, 5 oz. Water, 50 gallons.

				Variety unknown.											
1 Seed nearly free from Scab	4-24	14	48	46	1	2	1	14	3	10	6	10	3	.....	1 hour.
2	4-24	14	48	44	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1½ hours.
3	4-24	14	48	41	1	6	2	9	5	8	9	7	3	15	2 hours.
1	4-24	14	48	46	2	10	7	8	1	6	11	8	10	2	Check.

POTASSIUM SULFID.

Potassium Sulfid, 2 ounces; water 8 gallons.

Variety unknown.

No.	Time of planting.	Weight of seeds.	No. of hills planted.	May 6th, No. up.	Very scabby.		Slightly scabby.		Clean.		Total.		Total scabby.		Time of application.
		Lbs.			Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	
1	4-26	15	48	48	4	9	3	2	7	7	15	2	7	11	2 hours.
2	4-26	15	48	48	5	10	5	9	0	0	11	3	11	3	1½ hours.
3	4-26	15	48	48	2	9	7	6	10	7	21	6	9	15	1 hour.
4	4-26	15	48	48	9	6	7	2	0	0	16	8	16	8	Check.

BORDEAUX MIXTURE.

Copper sulfate, 6 pounds; lime, 4 pounds; water, 22 gallons.

1	Seed nearly free from scab	4-26	14	48	39	0	0	4	2	10	3	14	5	4	2	2 hou rs.
2	Picked	4-26	14	48	46	1	14	5	9	2	3	9	10	7	7	1½ hours.
3	Some scabby seed	4-26	14	48	44	2	4	8	11	6	0	16	15	10	15	1 hour.
4	Small scabby seed	4-26	14	48	44	6	14	11	12	0	0	18	10	18	10	Check.

BORDEAUX MIXTURE.

Formula like the preceding, with the exception of the lime, which was 6 pounds.

1	4-27	.....	48	40	2	14	5	10	5	13	14	5	8	8	2 hours.
2	4-27	.....	48	47	3	5	5	14	1	11	10	14	9	3	1½ hours.
3	4-27	.....	48	47	1	14	5	13	4	6	12	1	7	11	1 hour.
4	4-27	.....	48	39	4	3	14	8	3	4	21	15	18	11	Check.

FERROUS SULFATE.

Ferrous sulfate, 40 ounces; water 10 gallons.

Variety unknown.

No.	Time of planting.	Weight of seeds.	No. of hills planted.	May 6th, No. up.	Very scabby.		Slightly scabby.		Clean.		Total.		Total scabby.		Time of application.
		Lbs.			Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	
1 Seed nearly free from scab.	4-27	13	48	43	1	3	8	15	7	11	17	13	10	2	2 hours.
2 " " " " .	4-27	13	48	46	2	12	5	7	10	7	18	10	8	3	1½ hours.
3 " " " " .	4-27	13	48	46	1	4	8	6	11	4	20	14	9	10	1 hour.
4 " " " " .	4-27	13	48	46	2	2	4	6	4	4	10	12	6	8	Check.

SODA HYPOSULFITE.

Sodium hyposulfite, 2 ounces; water, 10 gallons.

1 Seed nearly free from scab.	4-27	12⅓	48	46	0	0	6	11	14	4	20	15	6	11	2 hours.
2.....	4-27	12⅓	48	41	0	0	4	1	6	13	10	14	4	1	1½ hours.
3.....	4-27	12⅓	48	48	0	0	8	5	19	10	27	15	8	5	1 hour.
4.....	4-27	12⅓	48	46	0	0	6	10	12	4	18	14	6	10	Check.

SULFUR SOLUTION.

Sulfur, 1 pound; water, 7 gallons.

1 Seed nearly free from scab	4-27	12	48	46	1	5	7	1	9	4	17	10	8	6	2 hours.
2 " " " "	4-27	12	48	48	5	2	5	11	1	9	11	12	10	13	1½ hours.
3 " " " "	4-27	12	48	48	4	6	13	4	6	6	24	0	17	10	1 hour.
Check " " "	4-27	12	48	48	3	14	6	5	3	12	13	15	10	3	Check.

The results here indicated are so discordant that no general conclusions can be drawn. This was largely owing to the peculiar season. It will be seen from these tables that the total product is by no means uniform; this can hardly be ascribed to the fungicide used, but no doubt to unfavorable conditions of the weather. I believe that bichloride will give best results.

The result obtained by the different fungicides can best best be seen in the following table:

FUNGICIDES.	Time, hours.	Total scab.	Total yield.
Bichloride of Mercury	1	8.10	17.15
Bichloride of Mercury	1½	6.7	18.1
Bichloride of Mercury	2	4.1	12.10
Check	....	6.10	15.3
Ammoniacal Carbonate of Copper	1	3	6.10
Ammoniacal Carbonate of Copper	2	3.15	9.7
Check	....	10.2	11.8
Potassium Sulfid	1	7.11	15.2
Potassium Sulfid	1½	11.3	11.3
Potassium Sulfid	2	9.15	21.6
Check	....	16.8	16.8
Bordeaux mixture	1	7.11	14.5
Bordeaux mixture	1½	9.3	10.14
Bordeaux mixture	2	8.8	12.1
Check	....	18.11	21.18
Ferrous sulfate	1	9.10	17.13
Ferrous sulfate	1½	8.3	18.10
Ferrous sulfate	2	10.2	20.14
Check	....	6.8	10.12
Soda Hyposulfite	1	8.5	20.15
Soda Hyposulfite	1½	4.1	10.14
Soda Hyposulfite	2	6.11	27.15
Check	....	6.10	18.14
Sulfur solution	1	8.6	17.10
Sulfur solution	1½	10.13	11.12
Sulfur solution	2	8.6	24.0
Check	....	10.3	13.15